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ELIMINATION OF ENGINEERING STUDENTS.

BY H. W. TYLER,

Vice-President of the Society.

It is doubtless impossible to add anything new to the discussion of this subject in the reports of the Committee on Coordination and Investigation, but some of the statements in the reports have been curiously and unfortunately misinterpreted. It has been said, for example, that "The appalling waste of the present haphazard methods of discovering individual capacity is forcefully revealed in a recent report of the current investigation of engineering education. This states that 60 per cent of the students in engineering colleges come from the top third of high school classes and 37 per cent more from the middle third. But though 97 per cent of the students are thus of demonstrated intelligence, only 28 per cent of them graduate in the specified four years; the other 72 per cent are 'weeded out' as incompetents or misfits. . . . By continued experimentation and perfection of these procedures, they might soon invert their present record by eliminating 28 per cent and graduating 72 per cent of those admitted."

Now the actual facts as published in recent issues of this JOURNAL are quite different and much less discreditable to the engineering colleges. It appears that the leading cause for leaving college is financial and that in less than a quarter of the cases was scholastic failure the chief reason. Other causes include: lack of interest in engineering; voluntary change of course; war service; health; family conditions, etc. Moreover, in the widely varied cases grouped under scholastic difficulty were included as contributory causes: self-support, time spent in commuting, social diversions, athletics and other college activities. While engineering institutions will prob-

ably continue to attract a sufficient number of serious and capable students, it would be a real calamity if the public impression should be created that engineering studies were too difficult for any but supermen or that the institutions were conducted with so little intelligence or so little humanity as might be inferred from the criticism.

THE SUPPLEMENTARY ACTIVITIES OF ENGINEERING COLLEGES
GRADUATE COURSES, ORGANIZED RESEARCH, EXTENSION COURSES, AND OTHER SERVICES.*

Purposes.—The purpose of this study was to prepare an inventory of the services rendered by engineering colleges of the United States and Canada other than those connected with the regular, full-time undergraduate courses.

Sources of Data.—Information was obtained by means of questionnaires circulated to all colleges and schools of engineering of the United States and Canada which offer courses leading to degrees. In certain cases other data were obtained from catalogues and verified by correspondence. One hundred and fifty-one of the one hundred and sixty-four institutions supplied information. In the thirteen which did not, engineering is a very minor activity. It is believed, therefore, that the information given on the following pages is substantially complete. Every effort has been made to have it accurate.

Many services rendered by engineering colleges are of such a nature that they cannot be classified definitely or stated in quantitative terms. The tabulations which comprise the body of the results of the survey include most of the important services which can be expressed quantitatively. These fall into a number of classifications to each of which one tabulation has been devoted. Those services which cannot be expressed in this manner are commented upon.

Auspices.—The study was conducted under the sponsorship of the Committee on Supplementary Services and Facilities of the Engineering Colleges:

Harold Pender, *Chairman*, University of Pennsylvania,
Edward H. Rockwell, *Secretary*, Rutgers University,
C. M. Allen, Worcester Polytechnic Institute,
H. S. Evans, University of Colorado,

* Bulletin Number 5 of the Investigation of Engineering Education. Copyright, 1926, by the Society for the Promotion of Engineering Education. Contents may be quoted with reference to the source.

Anson Marston, Iowa State College,
C. R. Richards, Lehigh University.

The material which follows is based upon the report of the committee which was presented in June, 1926.

Summary of Results.—The results of the survey, taken as a whole, indicate that engineering colleges recognize that the needs of industry which the colleges are directly or indirectly in a position to supply extend far beyond undergraduate instruction. The tabulations include a variety of instructional work which aggregates a considerable total. As might be expected, the tax-supported institutions supply these supplementary services to a much greater extent than do the privately endowed colleges and universities. These activities are not, however, confined exclusively to the tax-supported institutions, and many of the privately endowed institutions report extensive supplementary activities. While no study has been made of the dates of establishment of the "supplementary" activities included in this survey, it is known that many activities of this character are of comparatively recent origin and that their growth is becoming progressively more rapid.

Organized Engineering Research and Testing.—Table 1 gives a summary of expenditures, personnel, and publications relating to engineering research and testing carried on under the direction of engineering colleges. The information was supplied in answer to a question as to whether the institution carried on organized research in the field of engineering other than that undertaken by individual members of the staff on their own initiative. If answered in the affirmative, this question was followed by a request for detailed data.

It will be noted that sixty institutions in the United States and four in Canada are listed. These institutions either have a definitely organized research division, or carry on research or testing work under the direction and control of the engineering department. In several cases, however, while there is provision for a research division, no expenditures have been made and no projects have as yet been undertaken. Only

forty-three of the sixty institutions in the United States report expenditures for research in 1924–25, and but twenty-nine report expenditures of $5,000 or more per year. Seventy-five per cent of the total expenditures are reported by ten institutions and ninety per cent by twenty-two institutions. It is evident that the bulk of the research work in engineering is done in comparatively few colleges.

It should be noted that in a number of institutions there is much valuable research work done which is not undertaken under the direct supervision of the institution itself. At such institutions as Harvard, the University of Pennsylvania, the University of Pittsburgh, Columbia University, and several others, important contributions to knowledge through engineering research are made each year. Due to methods of organization and budgeting of expenses in such institutions, it is not possible to make a separation either of expenditures or of time spent by members of the staff in research. In this respect the table is incomplete. It is not possible to estimate the increments to the tabulation which would result if the research work of these institutions were included.

Limitations of Data on Research.—In studying the table it should be remembered that the word "research" is susceptible of different interpretations by different individuals and that it is often difficult to distinguish between genuine research and what may more properly be designated as development work or engineering testing. An effort was made to exclude testing of a purely routine character, but it is not certain that expenditures for some work of this kind are not included. It is quite possible that if the tabulation were limited to really fundamental research, the figures might be appreciably smaller.

It is apparent also that the data given by the various institutions are not directly comparable, due in large part no doubt to different interpretations of the questions asked. For example, one institution reports a research staff of three full-time men, and yet reports no funds for research. Another institution reports a total of $139,000 expended for research

during the year 1924–25, and a staff of fifty-two full-time men, but reports no publications to date and no projects under way in June, 1925. On the other hand, another institution, with approximately the same research budget, reports eighty-five research projects under way on June 1, 1925. In spite of these inconsistencies, all of which could not be eliminated, the combined data serve to indicate the extent of the research activities of the engineering colleges.

Summary of the Research Situation.—For the institutions listed in the table the total amount expended during the year 1924–25 on engineering research was $1,304,132. Including institutions, such as Harvard, University of Pennsylvania, Princeton, Yale, etc., which report no separate research organizations, this total would probably reach $1,500,000. This, compared with the $30,000,000 expended annually for undergraduate engineering training, indicates that at the present time engineering colleges are devoting about five per cent of their annual income to engineering research and tests.

In view of the importance of engineering research to the industries, both directly and through the training of research workers and competent engineering teachers, this annual expenditure of $1,500,000, although seemingly large in the aggregate, is entirely inadequate. At least four industrial concerns each exceed this sum in their annual expenditures for research.

It may also be concluded from the tabulation that relatively few institutions are carrying on engineering research on an extensive scale, and that there are no organized research activities whatever in about two-thirds of the engineering colleges.

Graduate Courses.—Graduate courses in engineering are offered by more than half of the institutions in the United States, as shown by Table 2. The number in which there are enrollments, however, is slightly smaller—seventy-seven institutions. It is to be noted that seven-eighths of the total enrollment is in ten institutions. One institution alone has twenty per cent of all of the graduate students in engineering.

The ratio of enrollments in graduate courses for 1924–25 to the number of graduates obtaining first degrees in 1924, is approximately twelve per cent. This seems to be a reasonable proportion. The ratio of the number of advanced degrees to first degrees is approximately seven per cent.

A careful study of the returns indicates that in a considerable number of the colleges the courses offered are largely on paper and that actually the graduate work is not on a definite going basis.

Graduate Degrees.—Of the 522 advanced degrees shown in Table 3 as granted in 1925, only eight were of the grade of doctor, the others being the degree of master or equivalent. This indicates clearly that practically all the graduate instruction in engineering consists of a single year's work superimposed upon the usual four-year undergraduate curriculum. It is also probable that in many instances this fifth year of so-called graduate work is merely an extension of the undergraduate curriculum to cover certain special topics for which there is not sufficient time in the regular four-year course. Real advanced instruction in the fundamentals of engineering is given in only a very few institutions. This is evidenced by the fact that most of the research workers in the large commercial laboratories are recruited, not from the engineering colleges, but from the graduate departments of physics and chemistry. In fact there are relatively few teachers of engineering who have had the fundamental training in mathematics, physics and chemistry to qualify them to give the type of graduate instruction needed by those who wish to prepare themselves specifically for high-grade engineering research.

In connection with the tabulation of advanced degrees it is to be noted that these are degrees granted for work in residence only and that professional degrees conferred on the basis of practical experience plus a thesis are not included. Advanced degrees conferred by graduate schools are included where it is clear that the work may properly be classified as engineering as distinguished from pure science.

Fellowships in Engineering.—Of the 150 institutions which

supplied information, fifty-two offer one or more fellowships in engineering. The total number of fellowships offered in 1924–1925 was 227, but of these 163, or 72 per cent, are really half-time teaching positions. Only sixty-eight unencumbered fellowships for full time graduate study in engineering are offered. It appears that the much needed advanced study in engineering could be greatly stimulated by the offering of a greater number of such fellowships.

The average stated stipend of the fellowships offered is $585, which is approximately half the average salary of a first-year instructor or assistant. It is to be noted that the stipends listed do not include amounts remitted for tuition fees. Had these been included, the stipends would have been considerably larger in many cases. They were not included for the reason that in many institutions the tuition fees are virtually nominal and, therefore, do not represent actual values.

Evening Courses Leading to Degrees.—Only six institutions offer evening courses in engineering *which lead to degrees.* Four of these are situated in New York City, one in Washington, and one in Pittsburgh. It is evident that provision for work of this character is not well distributed in the large centers of population.

That the same degree should be awarded for evening work as for the regular day courses may perhaps be doubted by some. To others it seems entirely feasible to provide adequate safeguards to insure the full equivalence of such evening work with the work done in the regular full-time program, and that when such precautions are taken the evening student should receive the same recognition as the attendant of the day classes.

Two general classes of students offer themselves for these courses. One class includes high school graduates who are unable for financial reasons to attend regular day classes. The other class includes the graduates and former students of engineering who wish either to take additional work or to complete their college course. Many of the latter are students who were obliged to leave college in order to earn a living.

It is the experience of institutions offering work of this character that the students are earnest and purposeful and that the classes are conducted in an atmosphere and with a spirit which are very impressive. The total enrollments in 1924–25 in the colleges which offer evening courses leading to degrees was approximately 3500 and the number of degrees conferred was 133.

It is a fair question to ask whether more work of this character could not be offered with advantage in the large industrial centers of the country. However, when funds are limited and the evening classes can not be made self-supporting, it is doubtful if such evening courses should be undertaken.

Evening Courses Not Leading to Degrees.—Twenty-one institutions offer work in engineering in the evening which does not lead to degrees. There is considerable diversity in both the type and character of this work, ranging as it does from graduate work to that of a purely vocational character. The institutions offering the work are for the most part located in large centers of population. On the other hand, there are many institutions located in large cities which offer no evening courses whatever. The twenty-one institutions all offer degrees in engineering in their regular day courses. None of the institutions such as Pratt Institute, Wentworth Institute, Franklin Union, Ohio Mechanics Institute, etc., which do not offer degrees for either day work or evening work, are included. The summary therefore does not give a complete picture of the provision in the evening for technical work of an intermediate character.

Provision for instruction in engineering and vocational work of the types listed in the table is a distinctly necessary and valuable educational work. Whether or not it is a proper function of the engineering colleges themselves may be open to question. However, it is worth noting that in the entire country there are but ten non-degree-granting institutions of a substantial character, such as those named in the preceding paragraph, which provide training of this type (excluding proprietary schools). This very significant fact should not

be lost sight of in any discussion of this particular phase of engineering education.

Short-term and Special Courses in Residence.—Thirty-one institutions offered short-term and special courses in residence in 1924–25 and the total enrollment in such courses was 3307. The courses vary widely in type, ranging all the way from short intensive courses for graduates or practicing engineers to those of a distinctly vocational character. The many titles of the courses are indicative of this. The institutions offering them are quite widely distributed geographically. A majority of them are publicly supported institutions.

Requirements for admission to short-term courses vary widely, but for the most part they are open to students having less than a complete high school training. In some cases, certificates are awarded upon completion of the work; in others, no credentials of any sort are given.

Eight institutions offer extra-mural courses. With the exception of a single institution, the enrollments in such courses are small. One institution offers a graduate extra-mural course. In the other institutions most of the extra-mural work is of a vocational character.

Correspondence Courses.—While sixteen institutions offer correspondence courses, practically all the registrations were reported by one institution. It is apparent that the engineering colleges have not embarked extensively on work of this character. Most of the subjects offered by correspondence are those of the first two years in engineering although some additional work of a more strictly technical character is provided for. The University of Wisconsin was a pioneer among the collegiate institutions in this work and has developed it to a much greater extent than any of the others. Some of the correspondence work is accepted toward the degree, but in no institution is the degree conferred for work in correspondence exclusively.

Other Services Rendered by the Colleges of Engineering.—In addition to the activities outlined in the foregoing paragraphs, the colleges supplied information regarding a number of other supplementary activities.

a. Of the 151 institutions reporting, 110 stated that individual members of the teaching staffs were engaged in engineering research on their own initiative or under the direction of the institution. This includes the institutions previously mentioned. It is significant to note that in forty-one institutions conditions are such that individual teachers do not engage in research.

b. Of the 151 institutions, 117 reported that routine engineering tests are conducted either by or in the name of the institution by individual members of the staffs. Thirty-four institutions reported that no work of this character is done. This number is approximately the same as the number reporting that no research work is done, and it is apparent that in a considerable fraction of the institutions undergraduate instruction constitutes practically the sole activity.

c. In a very few institutions there are definitely organized plans through which the services of the engineering staffs are made available in consulting capacities to the industries, public service utilities, departments of the state or municipality, or to others.

d. In addition to the foregoing activities, many of the engineering colleges, or members of their staffs, have definite connections with, or serve as members of, state or city commissions, boards of trade, engineering and industrial commissions, etc. Teachers of engineering are largely represented in the activities of the professional engineering societies, both in their governing bodies and in their technical committees. The colleges or individuals also act directly or in an advisory capacity in the educational work of industrial establishments. In a number of cases the colleges also compile and distribute data regarding the natural resources and the industries of the states, and are active in developing those resources. It is, of course, not possible to list the many additional activities such as the rendering of expert testimony, connection with numerous civic and state activities, and the like. Twenty of the institutions through their engineering departments maintain radio broadcasting stations and in some cases regular courses of instruction are given in this manner.

1. ORGANIZED ENGINEERING RESEARCH AND TESTING—1924 AND 1925.

Institutions in the United States.	Name of Department Devoted to Research.	Date Established.	Annual Engineering Research Funds.			Engineering Research Staff, All Grades.			Number of Publications Issued to June 1, 1925.	Number of Projects in Progress, June 1, 1925.
			Appropriation by the State.	Allotted by the College.	Funds from Other Sources.	Full Time.	Compensation in Part from Research Funds.	Part Time without Extra Pay.		
Alabama, University of	United States Bureau of Mines, Southern Experiment Station.	1919				3		2		3
Arizona, University of	Arizona Bureau of Mines.....	1915		25,530		3	6		118	4[a]
Arkansas, University of	Engineering Experiment Station	1920		5,700		1		4	1	3
California Institute of Technology	No Separate Department.....			70,000	69,000	52				
Carnegie Institute of Technology	Bureau of Metallurgical Research.....	1924		17,000		3	1		6	5
Cincinnati, University of	Institute of Industrial Research	1925			75,000	15	20			
Clemson Agricultural College[b]	Engineering Experiment Station	1924		2,000				3		2
Colorado Agricultural College[c]	Engineering Section of General Experiment Station.....	1918	10,900			3	4		5	5
Colorado School of Mines	Department of Metallurgy and Research.....	1912		28,820[d]		4				
Cornell University	Engineering Experiment Station	1923		7,000		3	3	8	288	
Florida, University of	No Separate Department.....				400					3
Georgia School of Technology	Department of Research and Tests.....	1922	3,500			1	2		5	
Idaho, University of	No Separate Department.....			1,000				1		
Illinois, University of	Engineering Experiment Station	1903		105,056	55,500	28	18	50[e]	167	85
Iowa State College	Engineering Experiment Station	1904	45,000	13,000	18,400	13	29	9	72	40

[a] All geological investigations considered as one project.
[b] Project is a materials survey of the State.
[c] All figures are for the Engineering Section.
[d] "State funds but out of our General Fund."
[e] Estimated.

1. ORGANIZED ENGINEERING RESEARCH AND TESTING—1924 AND 1925.—*Continued.*

[e] All figures are for the Engineering Section.

[g] Estimated.

1. ORGANIZED ENGINEERING RESEARCH AND TESTING—1924 AND 1925.—*Continued.*

Institutions in the United States.	Name of Department Devoted to Research.	Date Established.	Annual Engineering Research Funds.			Engineering Research Staff, All Grades.			Number of Publications Issued to June 1, 1925.	Number of Projects in Progress, June 1, 1925.
			Appropriation by the State.	Allotted by the College.	Funds from Other Sources.	Full Time.	Compensation in Part from Research Funds.	Part Time without Extra Pay.		
Iowa, State University of	Research in Hydraulics and Radio	1921	7,000		9,410[f]	3		4	3	9
Johns Hopkins University	No Separate Department			10,000	15,000	3		7	145	8
Kansas State Agricultural College	Engineering Experiment Station	1910		12,250		2	4	25	15	2
Kansas, University of	Engineering Experiment Station	1908		1,450	1,300		1	1	12	3
Kentucky, University of	No Separate Department			3,000		1				3
Lafayette College	No Separate Department				3,500				47	6
Lehigh University	Institute of Research of Lehigh	1924					2	1	3	28
Lewis Institute	Structural Materials Research Laboratory	1914			120,000[g]	40			18	25
Maine, University of	Engineering Experiment Station	1915	2,575			1	5	6	13	14
Maryland, University of	Engineering Experiment Station	1921		3,500	3,500		5	4		
Massachusetts Institute of Technology	Six Divisions of Research	1903		75,000	100,000	23	26		354	
Michigan State College	Engineering Experiment Station	1924		8,000		1	3	5		12
Michigan, University of	Department of Engineering Research	1920		10,000	60,601	8	94			60
Minnesota, University of	Engineering Experiment Station	1921		4,250			2[h]	15[i]	7	22
Missouri School of Mines	State Mining Experiment Station	1909	25,000		25,000[j]	5	4		28	1

[f] U. S. Department of Agriculture and Bureau of Public Roads.
[h] Portland Cement Association.
[h] Two half-time. Several by the hour.
[i] Estimated.
[j] United States Government.

1. ORGANIZED ENGINEERING RESEARCH AND TESTING—1924 AND 1925.—*Continued.*

Institutions in the United States.	Name of Department Devoted to Research.	Date Established.	Annual Engineering Research Funds.			Engineering Research Staff, All Grades.			Number of Publications Issued to June 1, 1925.	Number of Projects in Progress, June 1, 1925.
			Appropriation by the State.	Allotted by the College.	Funds from Other Sources.	Full Time.	Compensation in Part from Research Funds.	Part Time without Extra Pay.		
Missouri, University of	Engineering Experiment Station	1909	5,000				3	4	24	6
Montana State College	Engineering Experiment Station	1924								
Nebraska, University of	Engineering Experiment Station	1923			14,480	3	7	4		5
Nevada, University of	Engineering Experiment Station	1921		250				6	2	1
New York University	No Separate Department.....				18,000	2	8			30[k]
North Carolina State College of Agriculture and Engineering	Engineering Experiment Station	1923		28,000		1	2	13		14
North Carolina, University of	No Separate Department.....		7,500		7,500					1
North Dakota, University of	Mining Experiment Station....	1905	11,553	3,325	5,000[l]	2	12		25[l]	4
Ohio State University	Engineering Experiment Station	1913	10,000		1,000	4	28	17	44	20
Oklahoma, University of	Petroleum Engineering Course.	1924			500			1		2
Pennsylvania State College	Engineering Experiment Station	1908		15,780	500	6	2	8	36	6
Purdue University	Engineering Experiment Station	1917	24,890		49,200	14[m]	5	6	25	16
South Carolina, University of	Engineering Experiment Station	1924		2,000			3	3		
South Dakota State School of Mines	Mining Experiment Station....	1913	3,750			1	1			
Stanford University	High Voltage and Aerodynamics Laboratories.....	1916			1,662	2	5	19	9	20

[k] 25–30.
[l] Estimated.
[m] In addition, 30 men are employed on investigations in cooperation with the American Railway Association.

1. ORGANIZED ENGINEERING RESEARCH AND TESTING—1924 AND 1925.—*Continued.*

1. ORGANIZED ENGINEERING RESEARCH AND TESTING—1924 AND 1925.—*Continued.*

Institutions in the United States.	Name of Department Devoted to Research.	Date Established.	Annual Engineering Research Funds.			Engineering Research Staff, All Grades.			Number of Publications Issued to June 1, 1925.	Number of Projects in Progress, June 1, 1925.
			Appropriation by the State.	Allotted by the College.	Funds from Other Sources.	Full Time.	Compensation in Part from Research Funds.	Part Time without Extra Pay.		
Stevens Institute of Technology	Physics Research Department	1925			1,000				.	1
Tennessee, University of	Engineering Experiment Station	1921		1,000			1	5	7	1
Texas, Agricultural and Mechanical College of	Engineering Experiment Station	1914	2,000				1	2	30	3
Texas, University of	Engineering Experiment Station	1914	725	725		2	2		7	3
Utah, Agricultural College of	Agricultural Experiment Station	1918					2			4
Utah, University of	Engineering Experiment Station	1918	12,500	1,650	2,500[n]	3		6	16	4
Vermont, University of	Engineering Experiment Station	1922		1,500						
Virginia Polytechnic Institute	Engineering Experiment Station	1921		1,400			2	7	1	4
Washington, State College of	Engineering Experiment Station	1911[o]		5,000		1	1	5	16	4
Washington, University of	Engineering Experiment Station	1917	6,500				10[p]		32	12
Washington University	No Separate Department						1	7		8
West Virginia University	Engineering Experiment Station	1921		6,000	600		3	10	2[q]	10
Wisconsin, University of	Engineering Experiment Station	1914		6,000			3	10	54	
			178,393	467,186	658,553	257	331	278		
TOTALS—For Institutions in the United States			$1,304,132			866			1637	522

[n] Plus maintenance of buildings and a fellowship at $500.
[o] As a separate department in 1919.
[p] Time allowance, not cash, for research.
[q] Also 10 mining semi-research bulletins.

1. ORGANIZED ENGINEERING RESEARCH AND TESTING—1924 AND 1925.—*Continued.*

Institutions in Canada.	Name of Department Devoted to Research.	Date Established.	Annual Engineering Research Funds.			Engineering Research Staff, All Grades.			Number of Publications Issued to June 1, 1925.	Number of Projects in Progress, June 1, 1925.
			Appropriation by the State.	Allotted by the College.	Funds from Other Sources.	Full Time.	Compensation in Part from Research Funds.	Part Time without Extra Pay.		
Alberta, University of	Scientific and Industrial Research Council	1919	54,832[r]			11	5		10	4
McGill University	No Separate Department						2	12		
Nova Scotia Technical College	No Separate Department			500	2,000					
Queen's University	No Separate Department			1,000		1			6	8
Saskatchewan, University of	No Separate Department			15,000		2		15		20[e]
Toronto, University of	School of Engineering Research	1917	22,800		1,000	2	11		5[t]	14
			77,632	500	3,000	16	18	27		
TOTALS—For Institutions in Canada			$97,132			61			21	46
GRAND TOTALS—For Institutions in the U. S. and Can.			$1,401,264			927			1,658	568

Note: In several institutions in which research is done, there is no separate administrative organization for directing it and expenditures are not carried as a separate budget item. Such institutions are not included in the above table but are listed as follows: Harvard University, Columbia University, University of Pittsburgh, University of Pennsylvania, Princeton University, Yale University, Rensselaer Polytechnic Institute, and Worcester Polytechnic Institute.

[r] Supported by Provincial Government.

[e] Approximate.

[t] Contain 73 papers.

2. Graduate Courses in Engineering.

Institutions which offer Graduate Courses in Engineering 81
Institutions which do *not* offer Graduate Courses in Engineering .. 68
Institutions not replying 2

Total 151

Graduate Courses Offered.	Number of Institutions Offering Each Course.	Number Reporting 1924–1925 Enrollments in Each Course.	Total Enrollments in 1924–1925.
Chemical Engineering	44	17	156
Electro-Chemical Engineering	1	1	4
Ceramic Engineering	3	0	0
Oil Refining	1	0	0
Gas Engineering	1	0	0
Civil Engineering	58	23	98
Highway Engineering	2	0	0
Hydraulic Engineering	1	0	0
Municipal Engineering	1	0	0
Railway Engineering	2	0	0
Sanitary Engineering	6	3	9
Structural Engineering	2	0	0
Architectural Engineering	12	2	3
Electrical Engineering	59	21	232
Mechanical Engineering	57	20	92
Aeronautical Engineering	2	1	14
Marine Engineering	1	0	0
Flour Mill Engineering	1	0	0
Engineering Administration	1	1	3
Industrial Engineering	2	0	0
Mining Engineering	24	10	57
Metallurgical Engineering	12	6	13
Geology and Mineralogy	1	0	0
Oil and Gas Production	1	0	0
General Engineering	4	2	15
General Science	1	0	0
Agricultural Engineering	7	2	12
Forest Engineering	1	0	0
Textile Engineering	1	0	0
Trades and Industries	1	1	6
Unclassified	3	2	32
Totals	81	77	746 (49 Inst.)
Total—Unclassified Enrollments			256 (28 Inst.)
Grand Total			1,002 (77 Inst.)

3. ADVANCED DEGREES IN ENGINEERING.

Degrees Offered.	Number of Institutions Offering Each Degree.	Number Reporting Degrees Granted in 1924–25.	Total Number of Degrees Granted in 1924–25.
Doctor of Philosophy	18	2	7
Doctor of Science	5	1	1
Doctor of Engineering	2	0	0
Master of Arts	1	1	7
Master of Arts in Agri. Eng'g	1	0	0
Master of Science	38	21	212
M. S. with Designation	29	23	194
Master of Architecture	3	1	2
Master of Chemical Engineering	2	1	1
Master of Civil Engineering	4	1	5
Master of Electrical Engineering	4	2	7
Master of Gas Engineering	1	0	0
Master of Mechanical Engineering	4	2	13
Master of Science in Engineering	4	3	25
Master in Architecture	1	0	0
Master in Architectural Eng'g	1	0	0
Master of Applied Science	2	2	16
Agricultural Engineer	2	0	0
Architectural Engineer	1	1	1
Chemical Engineer	8	2	3
Civil Engineer	16	7	14
Electrical Engineer	14	8	13
Mechanical Engineer	14	7	23
Metallurgical Engineer	3	0	0
Engineer of Mines	4	1	3
Engineer in ———	1	1	25
TOTAL—Degrees	81	60	572 (60 Inst.)

Professional degrees such as C.E., E.E., etc. conferred on the basis of practical experience plus a thesis are not included in these summaries, but only degrees conferred for work in residence.

4. FELLOWSHIPS AVAILABLE TO GRADUATE STUDENTS OF ENGINEERING.

Institutions which offer fellowships in engineering 52
Institutions which do not offer fellowships in engineering 98
Institutions not replying 1

Total 151
Institutions which did not supply detailed information 4

Department or School in Which Offered.	Number of Institutions in Which Offered.	Total Number Offered in 1924–25.	Total Number Held in 1924–25.	Stated* Average Yearly Stipend.	Teaching and Research Work Required.
Chemical Engineering	15	26	26	$575	11 fellowships require none, others from 6 to 12 hours per week.
Civil Engineering	14	23	20	603	5 fellowships require none, others about ½ time.
Electrical Engineering	20	32	29	610	6 fellowships require none, others about ½ time.
Mechanical Engineering	15	32	24	550	9 fellowships require none, others about ½ time.
Mining and Metallurgical Engineering	13	49	48	688	29 fellowships require none, others about ½ time.
Architectural Engineering	4	7	3	683	About ½ time.
Other Engineering	10	14	14	598	About ½ time.
Not by Department or School	8	44	42	520	4 fellowships require none, others about ½ time.
TOTALS.....		227	206	Weighted Average $585	

Total fellowship funds available to graduate students of engineering, 1924–1925 ..... $120,000

* Some of the above fellowships carry remission of tuition fees, in part or entirely, but the cash values of these have not been reported.

5. EVENING COURSES IN ENGINEERING LEADING TO DEGREES.

Course Offered.	Number of Schools Offering Each.	1924–25 Enrollment.	Degrees Offered.	Number of Schools Offering Each.	Number of Degrees Granted 1924–25.
Civil Engineering	6	661	B.S. in C.E.	4	26
			C.E.	3	4
Chemical Engineering	5	285	B.S. in Ch.E.	3	18
			Ch.E.	3	3
Chemistry	3	174	B.S. in Chem.	3	6
Electrical Engineering	6	844	B.S. in E.E.	4	27
			E.E.	3	3
Industrial Engineering	1	12	B.S. in I.E.	1	0
Mechanical Engineering	6	750	B.S. in M.E.	4	38
			M.E.	3	5
Metallurgical Engineering	1	48	B.S. in Met. Eng.	1	2
Physics	1	8	B.S. in Physics	1	1
Students not Classified by Departments	3	698			
TOTALS.....	6*	3480			133**

* No students have been graduated from two of the institutions since the evening courses have been recently organized.

** This total does not include 15 graduates whose classification could not be determined.

6. Evening Courses in Engineering Not Leading to Degrees.

Twenty-one institutions offer evening courses in their engineering departments which do not lead to degrees.

Twenty of these institutions supplied detailed information regarding this work. Fifteen formally recognize the completion of courses; fourteen by awarding certificates and one by awarding diplomas. In three institutions certain certificates are given only upon completion of from one and one-half to three years of work.

Admission requirements vary with the subject to be pursued. In some cases they are determined by each instructor; and in a few cases there are no requirements for admission other than "ability to pursue the desired subject."

Five institutions report either no admission requirements or that less than a high school education is required.

Total enrollment in non-degree, evening courses in engineering during 1924–25	9,053
Total enrollment in institutions granting certificates, 1924–25	7,688
Total number of certificates conferred during 1923–24	1,110*
Enrollment in "diploma" courses, 1924–25	906
"Diplomas" granted in 1923–24	139

(* In some cases certificates are given only upon request.)

The following courses and subjects in which certificates or diplomas are awarded were reported:

Civil Engineering
Structural Engineering
Surveying
Graphic Statics
Municipal Engineering
Specifications
Architecture
Architectural Design
Architectural Drawing
Architectural Engineering
Building Construction
History of Architecture
Chemical Engineering
Electrical Engineering
Electricians' Course
Applied Electricity
Practical Electricity
Short Meter Course
Advanced Radio Engineering
Mechanical Engineering
Industrial Engineering
Machine Design
Machine Tools
Mechanism
Auto Mechanics
Heating and Ventilation
Machine Shop Practice
Methods of Apprentice Training
Foremanship
Mining Engineering
Blue Print Reading
Descriptive Geometry
Shop Arithmetic
Mechanical Drawing

7. Short Term Courses Offered by Engineering Colleges in Residence.

Courses Offered.	No. of Institutions Offering Each.	1924–25 Enrollment.
Chemical Engineering	2	1
Metallurgy, Mining and Assaying	8	116
Electrical Course (2 years)	2	24
Electrical Repair, etc.	5	39
Electrical Metermen's Course	12	580
Telephone Plant and Repairs	3	86
Mechanical Engineering (2 years)	2	15
Machine Shop	2	21
Auto Mechanics and Auto Operation	8	152
Gas Metermen's Course	5	219
Draftsmen's Course	2	14
Highway Engineering, Roadmaking, etc.	7	867
Total		2134

Courses Offered. (In one Institution only.)	1924–25 Enrollment.	Courses Offered. (In one Institution only.)	1924–52 Enrollment.
Applied Surveying (2 years)	7	Textile Engineering	8
Land Surveying, Short Course	7	Marine Engineering	0
Structural Engineering (2 years)	12	Stationary Engineering	0
Civil Engineering	0	Machine Design	0
City Planning (2 day conference)	50	Power Machinery (21 weeks)	48
Clayworking and Ceramics	61	Industrial Organization and Management	17
Ceramic Engineering	0	Power Plant Operators (3 days)	30
Marble Setters' Apprentice School	23	Ice Making and Refrigeration (2 days)	45
Industrial Group Round-up (2 days)	284	Operating (steam) Engineers (3 day conference)	200
Furniture Manufacturers' School (1 week)	15	Shop and Drawing Teachers (2 day conference)	50
Carpentry (12 weeks)	4	Mine Foremanship	11
Cotton Classing and Marketing	62	Colliery Engineering	0
Federal Trainees (2 years)	60	Blacksmith Trade Course (12 weeks)	6
Plumbers' Short Course	55	Blacksmith Trade Course (1 year)	9
Line Foremen (2 day conference)	107	Foundry Trade Course (1 year)	2
Total	747	Total	426

Institutions offering short term and special engineering courses in residence. 31
Total enrollment in short term and special engineering courses in residence 3307

8. Extra-Mural Courses in Engineering.

Courses Offered.	No. of Institutions Offering Each.	1924–25 Enrollment.	Conferred on Completion.
Graduate Study in Metallurgy	1	9	Graduate Degree
Metermen's Course	2	59	Certificate
Auto Mechanics (Elementary and Advanced)	1	28	Certificate
Elements of Factory Management	1	109	Certificate
Foreman Training	1	0	Certificate
Heat Treatment of Iron and Steel	1	1,293	Certificate
Power Plants	1	49	Certificate
Totals	8	1,547	

Typical Admission Requirements:

"Usual education, high school or less."

"Open to anyone interested in this subject."

"Open to foremen, factory executives and others interested in factory problems."

9. Correspondence Courses and Curricula in Engineering.

Sixteen institutions offer instruction by correspondence in engineering or in subjects required in the regular undergraduate engineering curricula.

During the spring of 1925, 6,171 active registrations in correspondence work were reported. Of these, 5,672 were reported by one institution. The next largest registration was 175. These registrations are by subjects rather than by curricula.

Six institutions offer a small amount of work by correspondence for college credit. Certificates are granted for completion of subjects or courses in institutions representing 5,777 of the total registration.

Over 200 subjects are catalogued under the following general headings:

Mathematics
Electrical Engineering
Structural Engineering
Drawing
Mechanical Engineering
Civil Engineering
Industrial Engineering

THE COSTS OF ENGINEERING EDUCATION.*

Purposes and Method.—The purposes of this study were to determine the costs of engineering education as accurately as possible; to express them in comparatively simple units; to determine the sources from which engineering colleges derive their revenues; and to determine the purposes for which funds are expended and the relative amounts expended for the several purposes.

Data on costs were obtained by means of questionnaires sent to all institutions of the United States and Canada which offer engineering curricula leading to degrees. Two such questionnaires were circulated, one during the year 1924–25 and the other during the year 1925–26. The first questionnaire was used in a preliminary way to obtain a rough idea of costs and to furnish experience upon which to base a more extended and thorough study to be carried out by means of the second questionnaire. Experience has demonstrated that it is impracticable to obtain figures from any considerable number of institutions on a uniform basis in greater detail than given herein. Every effort has been made to have the data on a strictly comparable basis and the scrutiny to which they have been subjected makes it reasonably certain that those which were retained for use are sufficiently uniform for present purposes.

Auspices.—The study was conducted under the sponsorship of the Committee on Supplementary Services and Facilities of the Colleges of Engineering:

Harold Pender, *Chairman,* University of Pennsylvania,
Edward H. Rockwell, *Secretary,* Rutgers University,
C. M. Allen, Worcester Polytechnic Institute,
H. S. Evans, University of Colorado,
Anson Marston, Iowa State College,
C. R. Richards, Lehigh University.

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Two reports on costs have been presented by the committee, one in June, 1925, based upon the preliminary study, and one in June, 1926, based upon the more thorough analysis. The second of these reports comprises the material which follows. The actual work of collecting and compiling the data and of writing the reports was done largely by Dean Edward H. Rockwell, secretary of the committee, who carried out the task as a special assignment.

* * * * * *

Sources of Information.—Fifty-five different institutions supplied usable information on costs. They are classified as follows:

Privately Endowed Polytechnic Institutes	9
Privately Endowed Universities	11
State Universities, including some Land Grant Institutions	16
Land Grant Colleges	7
State Schools of Mines	5
Miscellaneous institutions, including two Municipal Institutions, one partially state-supported Institute of Technology, one Military College, one Sectarian College, two colleges offering the junior and senior years only of engineering curricula	7

These institutions have not in all cases given complete information and it should be noted that the number of institutions and the corresponding number of students are not the same for computations summarized in the several tables. The number of engineering students registered in institutions included in the tables is in general about 22,000, there being 24,172 in the institutions of Table 1, or about forty-four per cent of the total number in the United States. The data are therefore believed to be sufficiently representative.

All of the information regarding costs was originally gathered together on one large chart, each institution being listed

in one of the above classifications. The totals on this chart were then analyzed in tables devoted to particular subjects as follows:

Table 1. Investment Devoted to Engineering Education.
Table 2. Sources and Amount of Income for Engineering Education.
Table 3. Expenditures for Engineering Education and Unit Costs per Student per Year and per Graduate.

These tables with graphical representations of the information contained in them constitute the substance of the results of this study.

Costs in Endowed Polytechnic Institutes.—It was stated in the preliminary report of June, 1925 that the most trustworthy results were those for the polytechnic institutes and institutes of technology, and this is also true for the present tabulations. This fact results from the difficulty of segregating the costs of engineering education in institutions which include other divisions of instruction. A comparison of these final results with those of the earlier report for this type of institution is as follows:

COSTS IN ENDOWED POLYTECHNIC INSTITUTES

	Report of 1923–24 Excl. Int. on Plant.*	Report of 1924–25.	
		Excl. Int. on Plant.	Incl. Int. on Plant.
Maximum cost per student per year...	$ 625	$ 712	$888
Minimum cost per student per year...	384	264	384
Average cost per student per year.....	551	571	750
Maximum investment per student....	14,000	14,250	
Minimum investment per student.....	2,120	4,000	
Average investment per student.....	7,854	10,750	

* The term "plant" signifies physical plant including land, buildings and equipment.

Comparison of Unit Costs by Types of Institutions.—A comparison of the average unit costs for five types of institutions given in the preliminary and final reports is as follows:

COMPARATIVE COSTS PER STUDENT

	Report of 1923–24 Excl. Int. on Plant.	Report of 1924–25.	
		Excl. Int. on Plant.	Incl. Int. on Plant.
Endowed Universities	$582	$582	$742
Endowed Polytechnic Institutes	551	571	750
State Universities	358	399	474
Schools of Mines	552	595	738
Land Grant Colleges	298	385	437

In the preliminary report no effort was made to determine the effect of "interest on non-productive plant" on the unit costs. The present report is based on complete data in relation to the value of plant which are in large part for July 1, 1925. In general there is a decided tendency toward undervaluation of plant and any costs including interest on plant are certainly below rather than above actual values.

Comparison with Non-Engineering Courses.—The following table shows the reported costs per student per year in courses other than engineering. Probably in no case do these figures include interest on plant. The costs for engineering students in these institutions are also given for comparison.

COST PER STUDENT PER YEAR IN COURSES OTHER THAN ENGINEERING, IN DOLLARS.

Key No. of Institution.	Agriculture.	Architecture.	Business Admin.	Chemistry.	Education.	Liberal Arts.	Law.	Medicine.	Cost in Engineering Excl. Int. on Plant.	Classification of Institution.
11						258	683	955	340	Municipal Institution.
14	304			300	300				303	Land Grant College.
16			281	281	281	281	383	1,152	418	State University.
26		200		200					354	Partially State-Supported Institute of Technology.
31	472		170		254	199	302	299	440	State University.
37	401		300		385	300	400		284	State University.
39			370			454			569	Privately Endowed University.
44							90	399	347	State University.
49	453	428		384		209	257	461		State University.
62			94		164	493	87	473	699	Privately Endowed University.
74	487		200		215				368	Land Grant College.
80						593			593	Privately Endowed University.
107		268			155	186	250		511	State University.
113									336	State University.
204			605			544		928	1,552	Privately Endowed College of Engineering in Graduate School.
215			264						384	Privately Endowed Polytechnic Institute.
258					250	250	214	500	383	State University.

Data on Investment in Plant and Endowments.—Table 1 contains the summary of the data in relation to investment in engineering education and gives information for forty-five institutions with 24,172 engineering students classified in accordance with the type of institution.

The table contains first, the investment as reported on the questionnaires. For all of the institutions except the institutes of technology and the schools of mines, the data pertains *only to that part of the plant distinctly used in engineering exclusively.*

For universities and land grant colleges the buildings, equipment and land used for general university purposes or for chemistry and physics are not included in the summary. In the universities and land grant colleges a part of the university plant other than engineering should be allocated to

engineering, perhaps in the proportion that the number of engineering students bears to the whole number. Under the conditions obtaining in the questionnaire, the comparison of figures is distinctly disadvantageous to the universities and land grant colleges. It is also proper to consider appropriations from federal, state or city sources as the income from a potential or effective endowment especially in comparison with other types of institutions having income from actual endowment. For these reasons the second part of Table 1 is an estimate of the probable effective investment represented. The item "additional value of plant" is an estimate based on evidence in the questionnaires as to the probable proportionate value of the university plant which might properly be credited to engineering.

The item "capitalized public appropriations" represents the sum that would produce the public appropriations at 5 per cent interest. The amounts of these public funds for the various institutions are given in the questionnaires.

The item "estimated total equivalent investment" is approximate, but it represents quite closely the actual situation and affords a fairer basis of comparison.

The weighted average investment per engineering student is $4,800 based on the reported values of property used strictly for engineering education only, whereas the "total estimated effective investment" raises the amount of investment per engineering student to $7,420.

The resulting values for total investment devoted to engineering education in the United States, based on a total enrollment of 55,000 students, are approximately:

$$\frac{55,000}{24,172} \times \$116,301,503 = \$265,000,000$$ investment as reported.

$$\frac{55,000}{24,172} \times \$186,645,503 = \$415,000,000$$ potential investment as estimated.

The first value of $265,000,000 is based on undervaluation

and incomplete listing of buildings, grounds and equipment used by engineering students in other related departments and in general educational activities, and is therefore known to be too small.

Data on Actual and Effective Income.—Table 2 shows the data regarding the sources and amount of income for engineering education for forty-six institutions having enrollments of 22,002 engineering students, classified according to the type of institution. The total income shown is $10,681,374, and from this figure the probable total income devoted to engineering education in the United States is approximately

$$\frac{55{,}000}{22{,}002} \times \$10{,}681{,}374 = \$26{,}700{,}000.$$

From Table 3 the interest at 5 per cent on plant (non-income producing investment) for 21,190 engineering students is $2,553,362, showing a probable total interest charge for 55,000 engineering students of

$$\frac{55{,}000}{21{,}190} \times \$2{,}553{,}362 = \$6{,}600{,}000$$

making a probable effective yearly total

cost for 55,000 engineering students = $33,300,000.*

Data on Tuition and Fees.—The information regarding tuition fees is not complete enough to compute the average fees charged in the different institutions. Table 2, however, shows complete information as to actual receipts from tuition and laboratory fees and therefore the average receipts based on the reported number of students gives accurate information as

* Though it would have been desirable to do so, it has not been possible to include an allowance for depreciation of physical plant in these figures. The principal reason for this is that there is no rational, agreed-upon method of computing depreciation of educational plant now available. Another reason is that it was not possible in the present study to obtain figures for the value of plant in sufficient detail to apply percentage allowances for depreciation to the several items comprising physical plant. If an arbitrary allowance of 2 per cent be made for

to the actual average fees paid to the institutions. These are seen to vary from a maximum of $275.36 per student to a minimum of $34.23 per student, with a weighted average for 22,002 engineering students of $172.02.

Table 2 shows the average income received by forty-six institutions with 22,002 engineering students to be $485.47, and Table 3 shows the computed average cost per engineering student exclusive of interest charges to be $486.38. These results were obtained from separate and distinct data, and as the income and expenditure ought to balance they afford a very close check.

Itemized Average Cost per Student.—Table 3 shows the average costs per engineering student for the different classes of institutions, also the weighted average cost for forty-two institutions with 20,594 engineering students, excluding interest on plant, as $486.38; and for forty-five institutions with 20,594 engineering students, including interest on plant, the average cost is $610.36.

From data given in these tables, the total average cost of educating one engineering student for one year is made up as follows:

Paid by one student	$172
Interest on plant	123
Endowment	124
Public appropriations	142
Other sources	49
	$610 *

The student pays 28.2 per cent of the cost; or, stated in another way, the results for about 22,000 students show that

depreciation of buildings and equipment (investment in buildings constituting nearly three-fourths of the total), approximately $2,000,000 would be added to the total cost of engineering education in the United States—the total cost would then be approximately $35,300,000. Similarly the cost per engineering student per year would be increased from $610 to $646.

about 28.2 per cent of the total expenditures comes from student fees.

Nominal Cost per Graduate.—It is of interest to divide the total cost for undergraduate instruction in one year by the number of men given first degrees in that year. This quotient has been called the "nominal cost per graduate" in Table 3, as it is not intended to imply that graduates are the only legitimate product of an engineering college, or that all expenditures are made in their behalf. Men who fail to graduate pay fees in proportion to the time of their attendance and doubtless profit from their partial courses.

It is shown in Table 3 that the nominal cost per graduate in forty-two institutions is $3,394, excluding interest, and $4,251 with interest included. It is shown in the preceding section that the average student pays $172 per year in fees and that this sum represents 28.2 per cent of the average total cost per student, including interest. A student who is graduated pays a total of $688 in four years, or 16.2 per cent of the nominal cost per graduate. The difference between the 28.2 per cent and the 16.2 per cent, or 12 per cent, is the part of the nominal cost per graduate covered by the fees paid by the non-graduates.

Summary Tables and Diagrams.—Plates I, II, and III, and Tables 1, 2, and 3 are self-explanatory and may be found on the following pages.

1. Investment Devoted to Engineering Education as Reported and the Estimated Total Effective Investment.

Number of Institutions.	Types of Institutions.	Number of Students.	Investment as Reported in Dollars.					Investment per Engineering Student as Reported.	Probable Effective Investment.			Total Estimated Effective Investment per Engineering Student.
			Endowment.	Buildings.	Equipment.	Land.	Total.		Additional Value of Plant.	Capitalized Public Appropriations 5%.	Estimated Total Equivalent Investment.	
9	Endowed Polytechnic Institutes	7,000	$48,027,278	$15,007,051	$4,418,334	$7,891,493	$75,345,156	$10,760	$.....	$ 440,000	$ 75,785,156	$10,800
10	Endowed Universities	3,479	11,205,254	6,128,359	1,848,139	886,088	20,067,840	5,760	8,000,000	3,580,900	31,647,840	9,100
10	State Universities	6,235	1,627,367	5,199,757	1,848,275	432,490	9,107,889	1,460	5,200,000	15,000,000	29,307,889	4,650
3	Schools of Mines	1,014	330,000	1,653,059	1,085,190	229,819	3,298,068	3,250	.....	12,324,000	15,622,068	15,400
7	Land Grant Colleges	2,620	224,901	1,689,662	796,370	146,000	2,856,933	1,080	2,500,000	12,600,000	17,956,933	6,850
6	Miscellaneous Institutions	3,824	484,901	2,702,575	1,879,976	558,165	5,625,617	1,470	2,200,000	8,500,000	16,325,617	4,260
45	Institutions	24,172	$61,899,701	$32,380,463	$11,876,284	$10,144,055	$116,301,503	$4,800 Weighted Average.	$17,900,000	$52,444,000	$186,645,503	$7,720 Weighted Average.

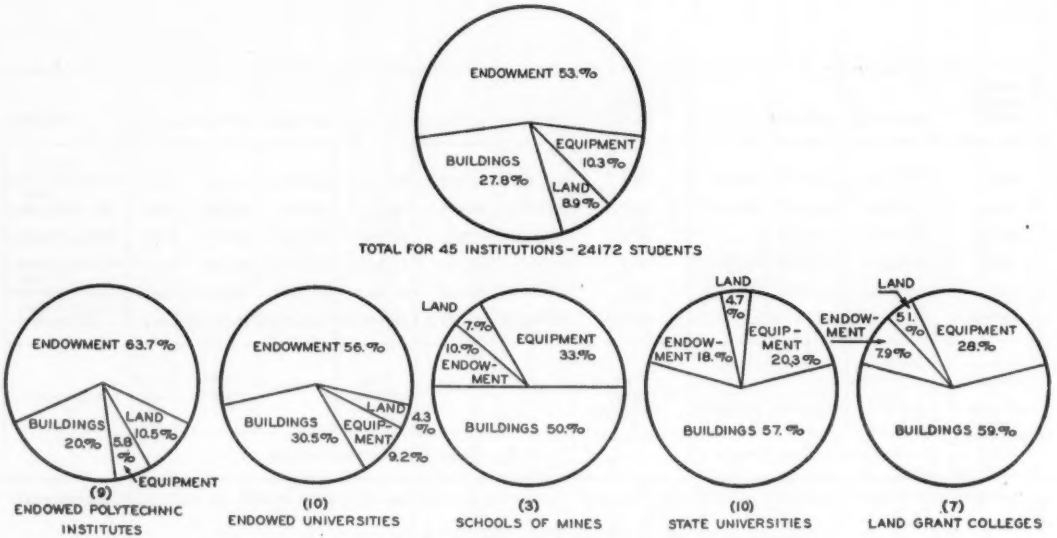


PLATE I. Distribution of Investment Devoted to Engineering Education.

2. Sources and Amount of Income for Engineering Education in Six Types of Institutions.

	No. of Institutions.	No. of Students.	Income from Fees.	Income from Endowment.	Income from Public Appropriations.	Income from Other Sources.	Total Income.	Average Fee Paid by Each Eng'g Student per Year.
Endowed Poly. Inst.	9	7,000	$1,927,495	$2,038,928	$ 23,000	$486,694	$4,476,117	$275.36
Endowed Univ.....	10	3,479	879,617	583,334	200,946	67,193	1,731,090	252.84
State Univ.....	10	4,505	259,585	25,650	1,118,905	74,404	1,478,544	50.96
Land Grant Col....	7	2,620	89,679	12,734	629,736	5,354	737,503	34.23
Schools of Mines...	4	1,237	83,284	20,682	875,118	181,224	1,160,308	67.32
Misc. Inst.....	6	3,161	545,218	25,595	264,582	262,417	1,097,812	172.48
Total for 46 Instit..		22,002	$3,784,878	$2,706,923	$3,112,287	$1,077,286	$10,681,374	$172.02 Weighted Average.

$\frac{10,681,374}{22,002}$ = $485.47 = Average Income per Student per Year.

From Table 3 $486.38 = Average Cost per Student per Year.

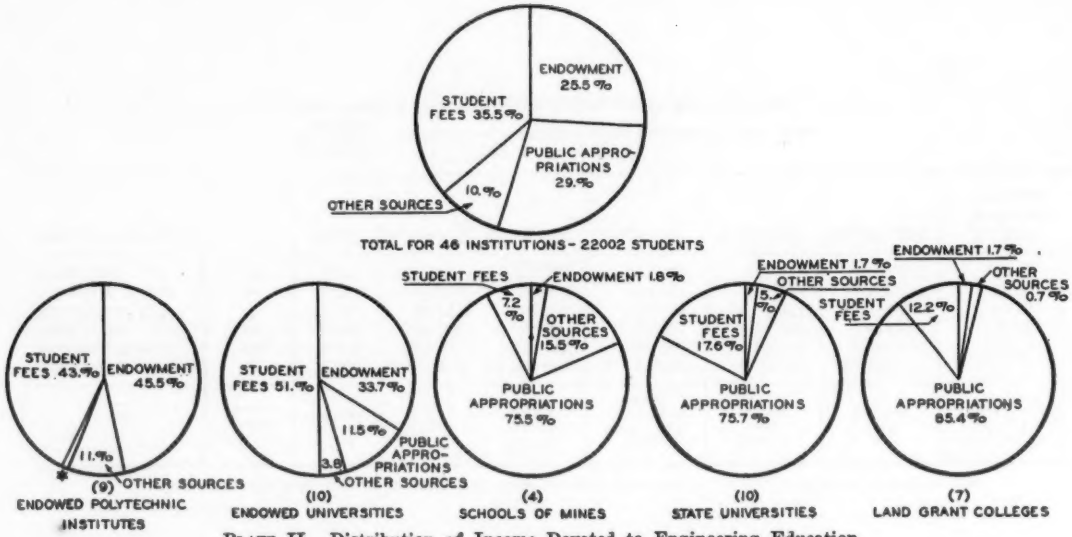
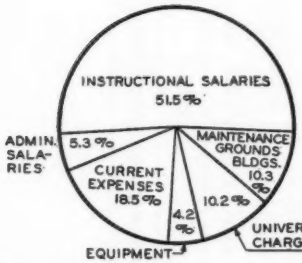

ENDOWMENT 25.5 %
STUDENT FEES 35.5 %
PUBLIC APPROPRIATIONS 29.%
10.% OTHER SOURCES
TOTAL FOR 46 INSTITUTIONS - 22002 STUDENTS
STUDENT FEES 43.% ENDOWMENT 45.5 %
11.% OTHER SOURCES
(9) ENDOWED POLYTECHNIC INSTITUTES
STUDENT FEES 51.% ENDOWMENT 33.7 %
11.5 % PUBLIC APPROPRIATIONS
3.8 OTHER SOURCES
(10) ENDOWED UNIVERSITIES
STUDENT FEES 7.2 % ENDOWMENT 1.8 %
OTHER SOURCES 15.5 %
PUBLIC APPROPRIATIONS 75.5 %
(4) SCHOOLS OF MINES
ENDOWMENT 1.7 %
OTHER SOURCES 5.2 %
STUDENT FEES 17.6 %
PUBLIC APPROPRIATIONS 75.7 %
(10) STATE UNIVERSITIES
ENDOWMENT 1.7 %
OTHER SOURCES 0.7 %
STUDENT FEES 12.2 %
PUBLIC APPROPRIATIONS 85.4 %
(7) LAND GRANT COLLEGES

PLATE II. Distribution of Income Devoted to Engineering Education.

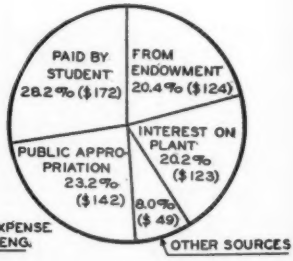
* State Scholarships and Federal Appropriations ½ of 1 per cent.

3. Expenditures for Engineering Education and Costs per Student per Year.

Number of Institutions.	Class or Type of Institution.	Number of Students.	Number Receiv'g First Degree June, 1925.	Instructional Salaries.	Administration Salaries.	Current Expenses.	Equipment, New and Replaced.	Building and Grounds Maintenance.	University Expense Charged to Engineering.	Total Expense Excluding Interest on Plant.	Interest on Plant.	Total Expense Including Interest on Plant.	Cost per Student per Year Excl. Interest on Plant.	Cost per Student per Year Incl. Interest on Plant.	Nominal Cost per Graduate Excl. Interest on Plant.	Nominal Cost per Graduate Incl. Interest on Plant.
9	Endowed Polytechnic Institutes	7,000	1,185	$2,062,041	$216,910	$1,058,527	$116,713	$540,152	$.....	$3,994,343	$1,252,834	$5,247,177	$570.62	$749.60	$3,390	$4,420
10	Endowed Universities	3,479	502	1,116,348	129,293	263,182	76,911	215,545	222,280	2,023,559	557,209	2,580,858	581.65	741.83	4,020	5,140
8	State Universities	3,332	422	584,051	35,809	130,391	75,578	121,820	381,990	1,329,639	248,044	1,577,683	399.05	473.49	3,160	3,740
2	State Universities	373	40	59,000	4,650	10,895	6,697	14,798	52,349	148,389	.....	.....	397.83	.....	3,700	.....
7	Land Grant Colleges	2,620	362	489,818	24,850	89,831	30,016	45,022	327,736	1,007,273	137,601	1,144,874	384.45	436.94	2,790	3,180
3	Schools of Mines	1,014	131	313,700	40,102	171,791	38,183	23,791	12,426	599,993	148,404	748,397	591.71	738.06	4,580	5,700
1	School of Mines	223	38	59,205	11,633	45,924	12,095	6,756	1,527	137,140	.....	.....	614.98	.....	3,610	.....
5	Misc. Institutions	3,149	355	612,355	80,843	149,384	72,588	93,588	52,982	1,061,740	209,180	1,270,920	337.12	403.59	3,000	3,590
45 Institutions		21,190	3,035	$5,296,518	$544,090	$1,919,925	$428,781	$1,061,472	$1,051,290	$10,302,076			$486.13		$3,394	
42 Institutions		20,594	2,957							$10,016,547	$2,553,362	$12,569,909	$486.38	$610.36	$3,394	$4,251



Distribution of Expenditures for Engineering Education.
Total for 45 Institutions—21,190 Students.



Sources from which Funds to Meet Cost per Engineering Student per Year are Obtained.
Cost Including Interest on Plant $610, Excluding Interest $487.

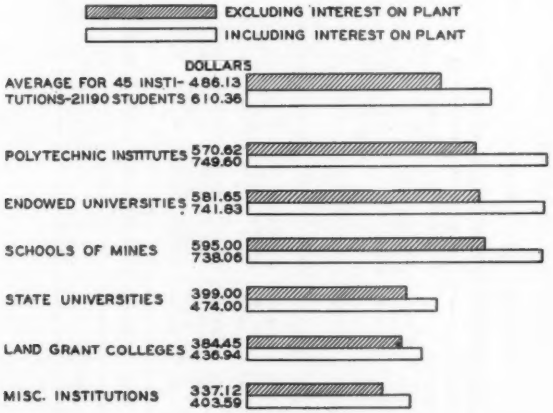


PLATE III.

Unit Costs in Engineering Education per Student per Year in Dollars.

DISCUSSION: THE ENGINEERING COURSE AS A GENERAL EDUCATION, MAY, 1926.

BY H. W. TYLER,

Vice-President of the Society.

An interesting article in the May number of the JOURNAL dealt with the engineering course as a general education, and more specifically with the status of mathematics as a field of study which might, on account of its difficulty and lack of intrinsic value to ninety per cent of the students taking it up, be replaced by (for example) the study of commercial law. It was suggested in the article that such applied subjects as strength of materials and hydraulics are successfully taught to students innocent of any knowledge of the calculus, therefore the latter cannot be of much real service and might be altogether eliminated, following the fate of differential equations, now taken only by students who expect to specialize in higher design. If one whose interests are primarily mathematical may be permitted to comment on this proposal and the arguments supporting it without any pretence of absolute impartiality, my own experience and observation have seemed to indicate that what students of applied science need most is training in exact quantitative thinking and clear expression. While the use of the notation of calculus and differential equations can of course be laboriously avoided, the underlying principles seem quite essential as well as highly economical for such thinking and expression. The technique of calculus *and* elementary differential equations once mastered affords an exceedingly clear and compact method of expressing the ideas in question. The elements of differential equations are for this purpose more important than the calculus; not much time need be spent on mere technique; the notions of limit and derivative can, and should, be taught to freshmen or earlier as is habitually done in other countries.

These notions, expressed perhaps, for the sake of brevity, too dogmatically, are submitted as the other side of the matter. Engineers trained in commercial law or in Greek syntax, or merely in "hard knocks" will continue to succeed professionally with little or no mathematics. It would be unfortunate (not merely for the mathematicians) if these exceptions became the basis for new rules.

SECTIONS AND BRANCHES.

New England Section.—The 11th meeting of the New England Section of the Society for the Promotion of Engineering Education was held at Worcester Polytechnic Institute, Worcester, Massachusetts, Saturday, October 23.

The morning session was called to order by Dean Anthony, Chairman of the Section, at 10:45. President Earle was introduced and extended a cordial welcome to the Section and gave a pleasing and instructive address relating to engineering education. The Chairman then instructed the Committee on Nominations which was appointed at the spring session to report during the evening session. This Committee was composed of Votey, Scott, and Russell. The records of the previous meeting at Massachusetts Institute of Technology were read and approved, after which announcements relative to this session were made by Dr. Duff. The Chairman then introduced Director Wickenden, who gave an inspiring address, taking for his subject "Is There Sufficient Encouragement to Self-Education in our Engineering Colleges?" This was followed by a discussion.

At 12:45 the members and officers were taken by automobiles to the new Alden Hydraulic Laboratory located at Chaffins, five miles from Worcester, where, as guests of the Institute, they were served a bountiful luncheon.

After lunch, Professor C. M. Allen gave a description of the laboratories, which was followed by an inspection of some of the tests by the students. About five o'clock the party returned to Worcester, where the high potential laboratory of the Electrical Engineering Department was thrown open for inspection.

At 6:30 the party repaired to the Gymnasium for dinner. Immediately following the dinner the Chairman called for a report of the Nominating Committee. The previous officers

were renominated and unanimously elected but begged leave to be allowed to resign. After a considerable debate which was finally brought to a head by the reading of the Constitution by the Secretary, their resignations were accepted. The Committee then brought in another report which resulted in the following officers being elected: Chairman, Professor W. H. Kenerson of Brown University; Secretary, Professor W. H. Timbie of the Massachusetts Institute of Technology. These officers were immediately inducted into office. A very pleasing address was then given by Professor C. F. Scott of the Board of Investigation and Coördination. The Chairman then called attention to the fact that he had two exhibits to present to the members and called upon Dean E. B. Norris of the University of Montana who is spending a year's leave of absence in the East. Dean Norris made a few very appropriate remarks. The Chairman then called upon Dean Paul Cloke, formerly Professor of Electrical Engineering at the University of Arizona, now the new Dean of Technology at the University of Maine. Dean Cloke concluded his remarks with a strong appeal to all of those present to come to the National Convention which is to be held next June at the University of Maine. The meeting was duly adjourned at about nine P.M.

Attendance at the morning session was about 80; at the noon luncheon, about 100; at the evening dinner, 75. The following institutions were represented: Brown University, Franklin Union, Harvard, University of Maine, Massachusetts Institute of Technology, University of Montana, Northeastern University, Norwich University, Rhode Island State College, Tufts College, University of Vermont, Wentworth Institute, Worcester Polytechnic Institute, Yale University, the Board of Investigation and the General Electric Company.

In order that there may be an official record, the Secretary upon his retirement desires to incorporate into these minutes a list of the meetings of the Section.

March 12, 1921, Worcester Polytechnic Institute
October 15, 1921, University of Maine

March 25, 1922, Brown University
October 28, 1922, University of New Hampshire
April 7, 1923, Wentworth Institute
October 27, 1923, Rhode Island State College
April 5, 1924, Yale University
October 11, 1924, University of Vermont
October 10, 1925, Norwich University
May 1, 1926, Massachusetts Institute of Technology
October 23, 1926, Worcester Polytechnic Institute

H. S. BOARDMAN,
Secretary.

Purdue Branch.—The Purdue Branch held its first meeting of the year in the Purdue Memorial Building on the evening of Monday, September 27. The speaker of the evening was Dean A. A. Potter, of the Engineering Schools, who made a report to the Section on the Iowa meeting of the S. P. E. E. Most of the evening was taken up by Dean Potter in a discussion of the fact-finding stage of the S. P. E. E. investigation of engineering education. This talk was illustrated with slides showing some of these facts in graphic form and provoked considerable discussion from the members. The attendance was seventy.

The second meeting of the Purdue Branch of the S. P. E. E. was held in the Library Lecture Room, Thursday, October 21. The speaker of the evening was Professor W. M. Hepburn, of the Purdue faculty, who addressed the members of the Branch on the subject, "The Engineer and the Library." In his interesting presentation of this subject, he gave statistics of the number of books and magazines published in the interests of engineering education, the availability of reference material, and discussed the better uses which might be made of the United Engineering Societies' Library, as well as the local library, by engineering students. The attendance at the meeting was twenty-five.

J. L. BRAY,
Secretary.

ITEMS OF INTEREST.

As requested in your letter dated October 21, 1926, I am returning, herewith, the list of those on our faculty who are members of the S. P. E. E., together with the list of those who, in my opinion, should belong.

Perhaps I should not have taken the liberty of making these corrections in red pencil and of checking the names of those who attended the convention, last June, at Iowa City. I think we made ourselves proud so far as the matter of attendance goes.

Editor's Note: Nine at the convention. $9 \times 800 = 7{,}200$ maximum miles traveled.

I wish to acknowledge receipt of your letter of the 21st instant with reference to membership in the Society and to say that I am adding the names of a number of members of our engineering faculty who I am sure are interested in the work which the Society is doing, and some of whom I hope will be willing to manifest their interest by becoming members of the Society.

With reference to the reports appearing in the JOURNAL OF ENGINEERING EDUCATION of the results of the investigation which the Society has been conducting for the past three years, I wish to say that I am placing a full set of these reports in the hands of President ....., Dr. ....., of our engineering faculty, who was our contact man during the investigation period, and also in the hands of each head of department in the engineering division.

COLLEGE NOTES.

University of Southern California.—Two new faculty members, Professor Thomas Eyre and William G. Angermann, have been appointed to the staff in Electrical Engineering this year at the University of Southern California, as recently announced by President von KleinSmid.

Due to rapidly increasing enrollment in this department, it has been necessary to add a professor of Mechanical Engineering, according to Professor Philip S. Biegler, chairman of the department.

Professor Thomas Eyre, for many years at Purdue University and Case School of Applied Science, and more recently Dean of Engineering at the University of New Mexico, has been selected to fill this position at Southern California.

Mr. Wm. G. Angermann, for the past two years Instructor in Electrical Engineering at Cornell University, becomes Instructor of Electrical Engineering at the University of Southern California, taking charge of the Electrical Engineering courses for juniors.

Tufts College.—Dean Gardner C. Anthony, dean of the Tufts Engineering School since its organization twenty-three years ago, tendered his resignation to the trustees of the college. The resignation was accepted, and Dean Anthony was relieved of active duty on September 1, but was granted a sabbatical leave of one year before finally retiring to pursue other interests. Dean Anthony is among the country's eminent engineering educators, and has been connected with Tufts for thirty-three years, as professor of graphics and dean of the Bromfield-Pearson School, and since 1903 as dean of the School of Engineering.

His college work was pursued at Brown and Tufts College until 1878, when he left to practice engineering in Providence. In 1887 he founded the Rhode Island Technical Drawing

School. This work he continued until his appointment at Tufts. In 1889 he received the master of arts degree there and in 1905 the degree of doctor of science was conferred upon him.

Dr. Anthony has been identified with various professional societies; he has been a member of the American Society of Mechanical Engineers since 1884, and since 1896 of the Society for the Promotion of Engineering Education, of which society he has served as vice-president and president. For several years he has been chairman of the New England section of the S. P. E. E. He is also a charter member of the American Association of University Professors. He has served upon several committees which have studied problems in engineering education, and is a trustee of "The Principia," a junior college in St. Louis.

Dean Anthony is also known as a writer of text books and scientific articles, especially his "Elements of Mechanical Drawing," "Machine Drawing," "Essentials of Gearing," and "Descriptive Geometry," forming the "Technical Drawing Series." In 1922 he published "An Introduction to the Graphic Language," and is the joint author of a forthcoming text in Descriptive Geometry.